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HEREDITARY FACTORS IN NORMAL PERSONALITY TRAITS (AS MEASURED BY INVENTORIES). LOUISVILLE TWIN STUDY, RESEARCH REPORT NUMBER 19.

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RESEARCH ON HEREDITARY FACTORS IN NORMAL PERSONALITY TRAITS, AS MEASURED BY INVENTORIES, HAS BEEN LIMITED BY THE FOLLOWING FACTORS--(1) DATA DRAWN FROM ADOLESCENT, NOT ADULT, TWINS, (2) OMISSION OF MENTALLY ILL TWINS, (3) SMALL SIZE OF SAMPLES, (4) VARIABILITY STUDIED ONLY WITHIN FAMILY, (5) SMALL, ISOLATED, UNCOORDINATED STUDIES, AND (6) PROBLEMS IN BASIC PERSONALITY THEORY. IMPORTANT THEORIES DISCUSSED ARE--(1) HYMAN'S EIGHT PERSONALITY TYPES AND THREE PERSONALITY DIMENSIONS, (2) JUNG'S SYSTEM OF FUNCTIONS, (3) VERNON'S SCHEMA OF VARIOUS PERSONALITY TRAIT RELATIONSHIPS, AND (4) SCHAFER'S THREE DIMENSIONS OF PARENTAL BEHAVIOR. REPORTS OF TWIN STUDIES OF PERSONALITY ARE ANALYZED. DYADIC POLARIZATION IN IDENTICAL TWINS MAY HAVE BEEN EXAGGERATED. THERE ARE NO IMPORTANT SEX DIFFERENCES OF BOY-GIRL TWINS IN PERSONALITY. THE STABILITY OF TWIN DIFFERENCES OVER TIME HAS BEEN PARTIALLY SUBSTANTIATED. THERE ARE CONSIDERABLE HERDITARY COMPONENTS IN PERSONALITY, BUT IT IS PREMATURE TO ESTIMATE THE PROPORTION. NEW QUESTIONNAIRES ARE NECESSARY TO STUDY THIS AREA. THE STRONGEST EVIDENCE FOR HEREDITARY FACTORS EXIST FOR EXTRAVERSON-INTROVERSION, EMOTIONALITY, AND ACTIVITY. THERE IS INDIRECT EVIDENCE FOR THE PRIMARY-SECONDARY FUNCTION, AND CONFLICTING EVIDENCE FOR NEUROTICISM. THE EVOLUTIONARY SIGNIFICANCE OF THESE PERSONALITY VARIATIONS WAS HYPOTHESIZED. (WR)

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RESEARCH REPORT

FROM THE

LOUISVILLE TWIN STUDY

CHILD DEVELOPMENT UNIT

DEPARTMENT OF PEDIATRICS

UNIVERSITY OF LOUISVILLE

Hereditary factors in normal personality traits (as measured by inventories).

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Report No. 19

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Hereditary factors in normal personality traits (as measured by inventories) *

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In 1960 Gottschaldt reviewed the evidence on hereditary factors in personality in Volume 4 of a 10 volume German Handbook on Psychology. He described his report as less a presentation of established findings than a critical listing of problems and research hypotheses. He touched on the difficulty of generalizing from separate studies because of the great variety of personality theories used in the various studies.

Since that time, results from several large twin studies have been published in which different personality questionaires were used, adding to the problem of summarizing and interpreting the results. (Gottesman 1963, 1965, 1966; Scarr 1966; Vandenberg 1962, 1966; Reznikoff & Honeyman 1966). I hope to show that some progress has been made.

Before making an attempt to do so, several important limitations of this report are to be pointed out.

1. In the first place, the data to be discussed are almost exclusively drawn from studies of normal adolescent twins. While twins are probably not very different from non-twins, adolescent personality may be organized somewhat differently and is probably less fully integrated than adult personality. Furthermore, some of the tests used are not optimal for this age range. At this stage of knowledge, one can speculate what will happen with increasing age to concordance data for fraternal (DZ) and identical (MZ) adolescent twins, and how statistics derived from a comparison of DZ and MZ concordance rates would be affected. Some data from Gottschaldt (1960) which provide some information about this will be presented below.

2. A discussion of studies of twins in which one or both partner(s) are mentally ill will be omitted because this would (a) take too much space, (b) the relation between "normal" personality traits and later abnormal symptoms has not been clarified enough to allow fruitful discussion. An exception will be made for the shy-withdrawn introvert personality trait which will be considered a "normal range" variant of certain types of schizophrenia.

3. Although twins probably do not differ significantly from non-twins in the general distribution of personality traits other than dependence on friends (Miki et al. 1963, 1964), so that at least on that account valid conclusion might be drawn about hereditary

factors in personality, there are some other limitations. It is often difficult to administer personality questionaires, which are usually rather lengthy, to large number of twins under the limitations of time and money of the average research budget. The result is that while the number of individuals in most twin studies may seem impressive when compared with correlational studies of personality, it is, nevertheless, frequently not large enough to allow conclusions at the usual levels of significance. This is a consequence of the fact that it takes, in a sense, four subjects, i.e. a pair of fraternal and a pair of identical twins, rather than one person to build up the number of cases for significance tests. Of course this does not account for all failures in these studies to arrive at definite conclusion at the one percent or better probability level. Some of the measures may not be accurate enough or the traits not stable enough to permit evaluation of the often small differences between twins. If the MZ correlations are less than .50 one may be wasting one's time unless one wants to study why MZ twins are not similar. Replication, even on a small scale, can overcome some of the limitations of insufficient sample size because under certain conditions the significance levels reached in two studies may be multiplied to obtain a single p value.

4. Another limitation of twin studies is that only within-family variability is studied. One can probably make a good case for the argument that between-family hereditary variation will not contain dimensions which would not also be displayed in within-family hereditary variation, because all these variations are based on genes which would differ, on the average, 50 percent of the time in any pair of fraternal twins. On the other hand, Cattell has argued that the expression of some genes may be modified between families by attempts to conform to social norms and within families by division of roles. Some of his results tend to support this conjecture (Cattell et al. 1955, 1957).

5. A far more serious limitation hindering a rational evaluation is, in my opinion, based on the fact that most twin studies are small, isolated, one-shot affairs. This means that in effect its authors are amateurs, be they geneticists, anthropologists or psychologists of whatever nationality. While such studies can be valuable in adding one more brick, some of the bricks are placed so far from the building that they cannot be used. Often such studies are not based on a systematic choice of variables arrived at

after considering the full domain of personality differences. For the moment the number of personality tests which have been administered to twins is quite limited. Presumably important areas have not been explored. There is increasing communication between individuals interested in human behavior genetics (Vandenberg 1965, 1966b), but a program of interlocking studies calling for systematic replication and planned coverage of important variables selected according to a master scheme is lacking. Perhaps such a systematic effort cannot be planned but has to grow naturally, and future studies should take into account earlier work, more than seems to have been the case. Barriers to international cooperation have been evident in this research area.

6. Perhaps the most serious limitation of all—which has already been touched upon in the opening paragraph—is due to the rather chaotic situation which has existed for a long time in theorizing about personality differences and the generally highly individualistic attempts to capture these differences in theory, test or ratings. The situation has changed little since Eysenck (1952) mentioned this state of affairs. Surely if the development of intelligence tests called for large team efforts, personality tests cannot be developed on a shoestring by a single investigator.

There have been a number of wide ranging summaries of personality theories and of methods to assess personality differences, but even outside the area of twin research, experimental studies in which more than one approach to personality measurement was used are rare, even though only such studies would allow comparisons between the effectiveness of different approaches.

To provide at least some frame of reference for the evaluation of twin studies of personality I will make, in this paper, what is my first published attempt to integrate several rather different personality theories. This attempt is to be regarded as tentative and preliminary only. It has been influenced greatly by my recent reading of the impressive studies before the first World War of the Dutch psychologist Gerard Heymans. Because this work is not widely known, I will present a very brief summary of it in a few paragraphs. It is necessarily colored by a 50 year distance between us, reflected in major changes in views, even of what seem simple terms.

In what must have been a fantastic expenditure of time and insight, Heymans (1908) studied, all by himself, from one to three biographies of 110 famous individuals and listed the presence or absence of a number of personality traits and behavior patterns such as: long term preoccupation with a problem, rapid change of moods, many or few friendships, etc. He studied the joint occurence of these traits without the benefit of modern computers or even of electrical desk calculators, and arrived, partly intuitively, partly empirically, at a three dimensional description of personality. This description was a synthesis of his empirical findings and rather "literary" ideas selected from 19th century French and German theories about personality such as proposed by Malapert (1897), Paulhan (1894, 1903), Gross (1902) and others. In addition his theory gave new meaning to some of the age old typological labels such as sanguine or phlegmatic, based on humoral theories which have become firmly imbedded in normal usage in many European languages. Heymans and Wiersma (1906-1918) were able to obtain from 458 physicians completed personality questionaires on 2523 individuals belonging to families they knew well in their capacity as small town family doctors. They also used data furnished by teachers of about 3000 high school students. These questionaires were based on Heymans'personality theory and were to be used to test its internal consistency. To my knowledge this material has not been reanalyzed with modern computer techniques. I do not know if it is still preserved, nor whether it would prove feasible to code it on punched cards.

Perhaps partly because of the intervening World War, reports of these studies did not have much influence on the development of personality assessment in England or in the United States, although several French psychologists later adopted Heymans' approach (Le Senne 1945, Berger 1950, Gauchet & Lambert 1959) Maistriaux 1959).

Heymans used a diagram of a cube, shown in Figure 1, to illustrate his theory. The three basic bipolar dimensions are (1) degree of activity, (2) degree of emotionality and (3) relative predominance of primary or of secondary function.

Under activity, Heymans understood vital energy displayed in the over-all life pattern of meaningful behavior, and not physical activity which can be due to tenseness displaying itself in excessive mobility or action. Emotionality he defined as the ready

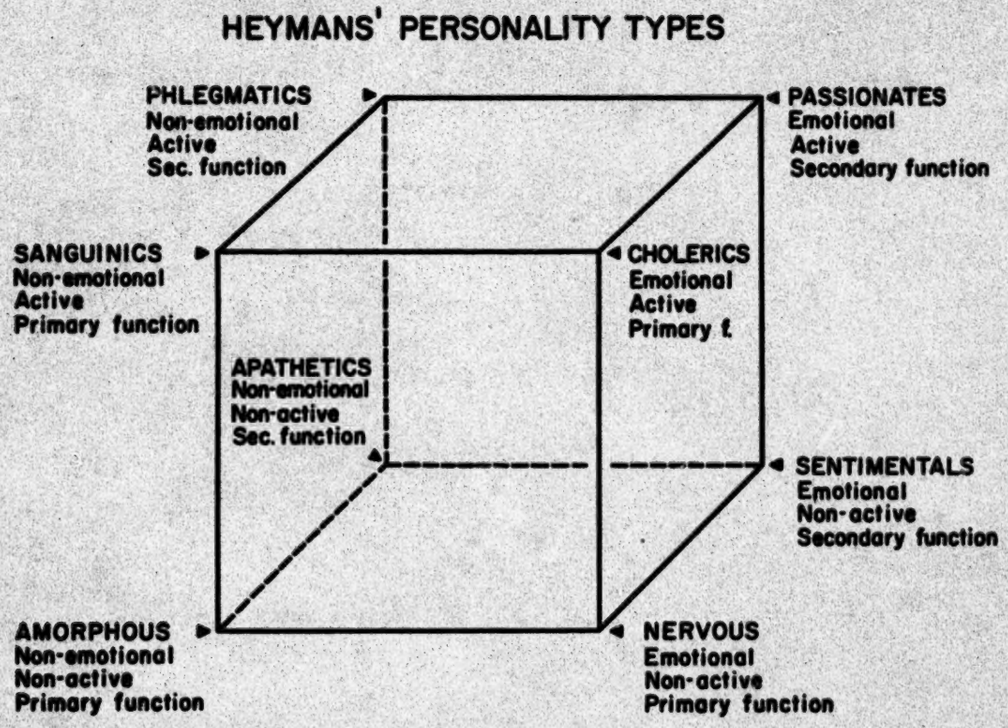

Fig. 1. A diagram of Heymans' three dimensional personality theory, with the eight types listed at the corners.

expression of emotions and the intensity of feelings and regarded as a rather valuable component of many personalities. His distinction between primary and secondary function he borrowed from Otto Gross (1902). When the primary function predominates, a person is more influenced by the impressions of the moment, while the predominating of the secondary function leads to greater influence of the residue of past experiences. This distinction was modified in Freud's conception of primary process and secondary process thinking, and probably also stimulated Pavlov's distinction between first and second signalling systems, in which the second signalling system is influenced by the accumulated meanings to be attributed to events reaching the first system. For Heymans the distinction did not imply a value judgment in favor of secondary function. Perhaps lack of concentration and perseveration might be regarded as the two undesirable end points. However, this forms no essential part of Heymans' conception. He regarded all three dimensions as essential and studied only normal

ranges of variation, although his collaborator, the psychiatrist Wiersma, studied some pathological correlates of the typology.

Whether or not one expects some relationship between normal personality dimensions and psychiatric illnesses depends at present largely, I would think, on whether or not one considers those psychiatric illnesses basicly "learned" i.e. an outcome of one's life history and especially one's reactions to it, or believes them to be basically biologically determined.

One would not expect a close connection for instance between a classification of automobiles and a classification of cause of breakdowns, but one would, between ways in which the cars are handled and the malfunctionings.

The eight corners of the cubes formed the "ideal" types i.e. the most pronounced embodiments of the combinations of extremes of the three dimensions. Most individuals would fall somewhere on the inside of the cube. The eight corner types were given the names shown in Table I. The table also shows what may be the most

Table I.

	Heymans' eight types			Jung's types
	Activity	Emotionality	Primary or Secondary Function	
Passionates	High	High	Sec.	Extr. Feeling t.
Cholerics	High	High	Prim.	Extr. Sensation t.
Phlegmatics	High	Low	Sec.	Extr. Thinking t.
Sanguinics	High	Low	Prim.	Extr. Intuitive t.
Sentimentals	Low	High	Sec.	Intr. Feeling t.
Nervous	Low	High	Prim.	Intr. Sensation t.
Apathetics	Low	Low	Sec.	Intr. Thinking t.
Amorphous	Low	Low	Prim.	Intr. Intuition t.

closely corresponding type of Jung's system, according to Krunz (1960) or Eysenck (1952). Heymans characterized some famous persons by the type they most closely resembled (1908). Thus he mentioned Napoleon as a passionate (EAS), Ben Franklin as a phlegmatic (nEAS) and Robespierre as a sentimental (EnAS). Many scientists resembled the phlegmatic type, although some he judged to be closer to the passionate

type. It would be interesting to compare some of Heymans' statements about scientists, which were based solely on biographies, with the findings by Bernice Eiduson (1962) and Anne Roe (1953) who used interviews and projective tests in their studies of scientists.

Recently Kouwer & Vander Werff demonstrated that Heymans' concepts still make sense today. They had 21 subjects do Q sorts on 120 statements selected from descriptions of their characterological types by Heymans (1948), Kretschmer and Pfahler (1954) among others. A factor analysis of these Q sorts led to four factors, three of which could be identified as (a) manifest emotionality, (b) vital energy or activity and (c) secondary-primary function.

Maistriaux (1959) analyzed a questionaire which contained 60 of Heymans' and Wiersma's 90 questions. Separate factor analyses for 923 men and 577 women were performed for ten variables: 1. emotionality, 2. activity, 3. secondary function, as well as 4. "largeur d'esprit", a concept related to the fertility or inventiveness of one's mind (creativity?). Variables 5, 6, and 7 were three dimensions of intelligent behavior (a) tendency towards generalization, (b) tendency towards particularisation, and (c) tendency towards conceptualizations based on items in the questionaire opposing theoretical or practical values. Variables 8, 9, and 10 were performance at the elementary secondary and college level. The results of the factor analyses are difficult to interpret with so few, oddly chosen, variables, but the correlations between the first three variables are -.26 (ExA), -.15 (ExS) and .35 (AxS) for the men, and -.16 (ExA), -.18 (ExS) and .32 (AxS) for the women. This gives support for the independence of these variables. In this apparently highly selected group of subjects who all obtained college level training, the correlations with the educational variables ranged from -.08 to .29.

Gauchet and Lambert (1959) also found partial confirmation for the three major factors proposed by Heymans in a French adaptation by Berger (1954) of Heymans' questionaire when analyzing correlations of groups of items. Figure 2 shows these three dimensions once more.

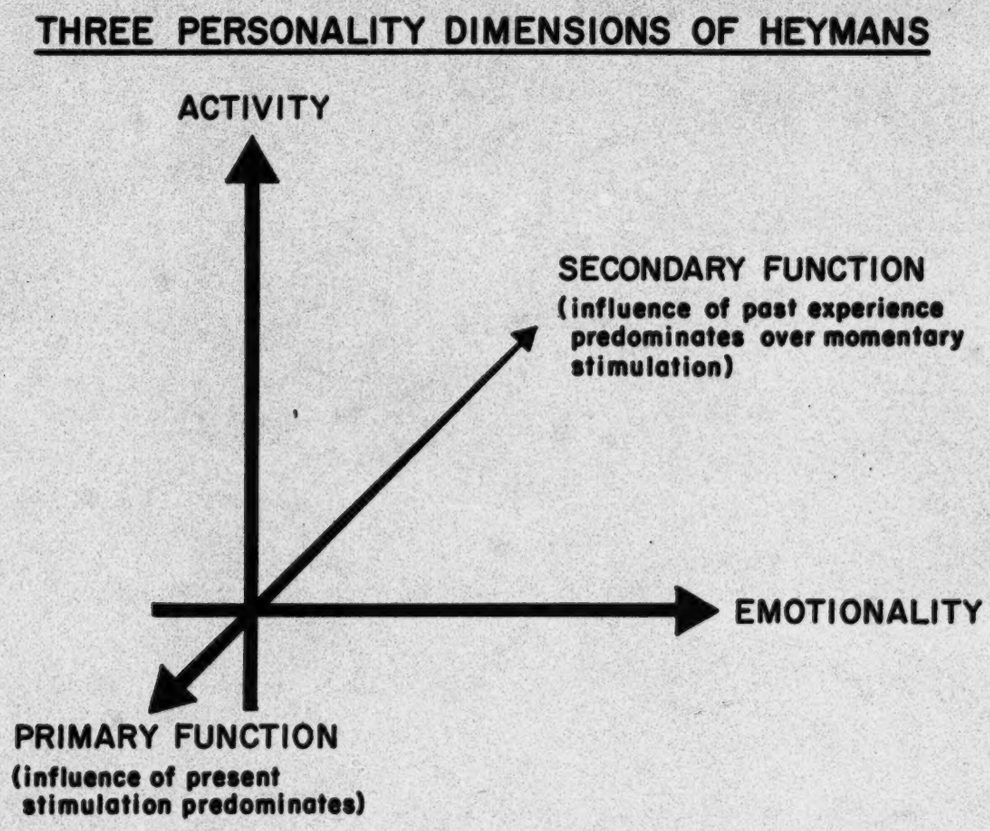

Fig. 2. The axes of Heymans' scheme shown separately.

Pfahler (1954) modified Heymans' ideas somewhat in his non-empirical book on "Erbcharacterologie" as may be seen from Figure 3, which represents a schematic summary of his ideas as abstracted by me from a paper by Krunz (1960). I have not read the original.

In spite of the fact that secondary function is not the same as perseveration, there is an obvious relation. On the other hand, Eysenck (1953) has suggested that the primary-secondary function dimension is identical with the extraversion-introversion continuum. Because introverts need not be high on perseveration, it is perhaps better to think of introversion-extraversion as a trait related to both emotionality and the primary-secondary function, bisecting the 90 degree angle between the axes defining emotionality and the primary-secondary function dimension in Heymans' system.

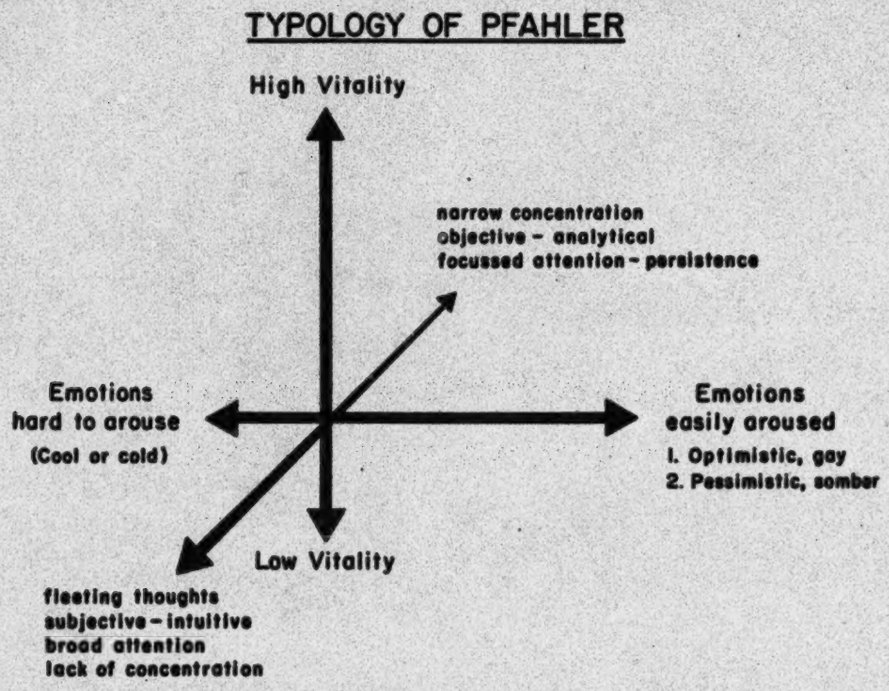

Fig. 3. The three dimensions of Pfahler's typology drawn so as to maximize the similarity to Heymans.

There is another possibility. When we look at a diagram of Jung's typology shown in Figure 4, we see another three dimensional scheme. The dimensions are extraversion versus introversion; thinking versus feeling, and intuition versus sensation, dimensions which may not be orthogonal. Without straining the analogy too much, one can perhaps equate the thinking-feeling dimension with Heymans emotionality axis, sensation-intuition with primary-secondary function. This leaves the introversion-extraversion dimension which surely is not the same as Heymans' activity axis. If we imagine a plane through the center of Heymans cube tilted towards us at the top, and draw a line on it slanting to the right at the top we may come closer. This would correspond to saying that the introversion-extraversion dimension is not orthogonal i.e. not uncorrelated with the other axes. Figure 5 shows how Jung's system might be fitted into Heymans' scheme. It assumes that none of Jung's dichotomies are exactly identical to Heymans' axes. For the moment

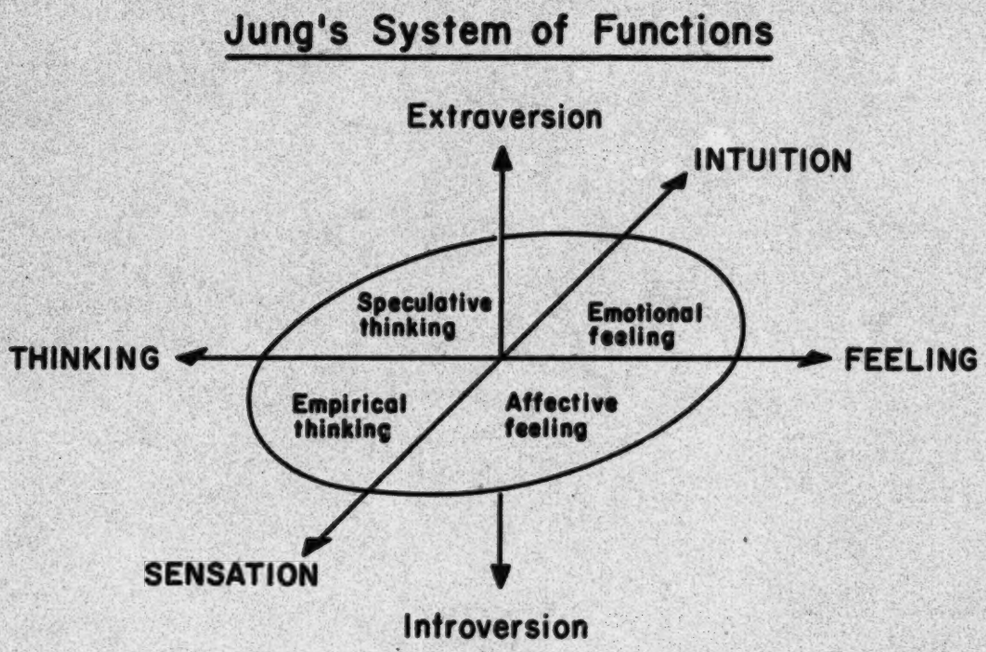

Fig. 4. Diagram of Jung's system of functions.

only the introversion-extraversion has been made oblique. The others may also be less than fully independent. Empirical data are lacking.

This scheme may provide somewhat more scope than the two dimensional integration of personality variables (based on empirical studies only) proposed by Vernon (1953) which is shown in Figure 6.

Vernon's schema is interesting because it introduces a valuation axis: dependable, integrated, good character versus undependable, poor character. This is probably due to inclusion of results from studies in which ratings of others were used. The addition of this dimension does, however, not leave much room for the other attributes. As a consequence they are rather crowded together. Thus we find emotional on the introvert side, and unemotional on the extravert side. This must be a somewhat different concept of emotionality than the one we have discussed before, it is close to neurotic and unstable. Persistance which forms one of

An attempt to fit Jung's typology into the system of Heymans

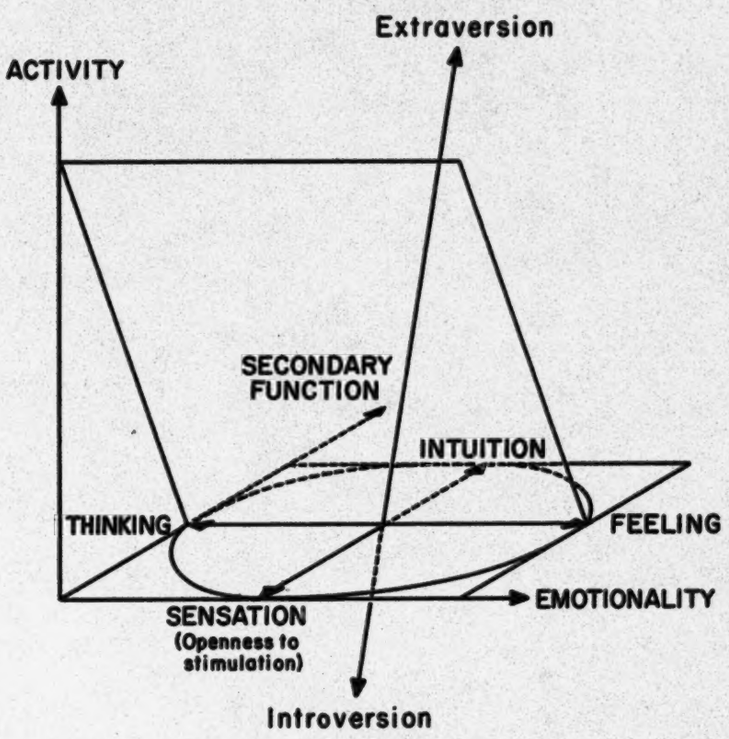

Fig. 5. Jung's typology fitted into the scheme of Heymans.

the characteristics of secondary function in Heymans' conception is in Vernon's scheme close to dependable. Yet one cannot simply equate secondary function and dependability because the former did not include a value judgment. Perhaps the many aspects of personality considered by Vernon needs more than two dimensions to be properly related to one another.

Factor analysis has familiarized some of us more with circles and spheres. If all three dimensions are equally long, a sphere is a more adequate representation because it allows for a more even distribution of persons along three dimensions without corners. The typologies just discussed could actually be better represented

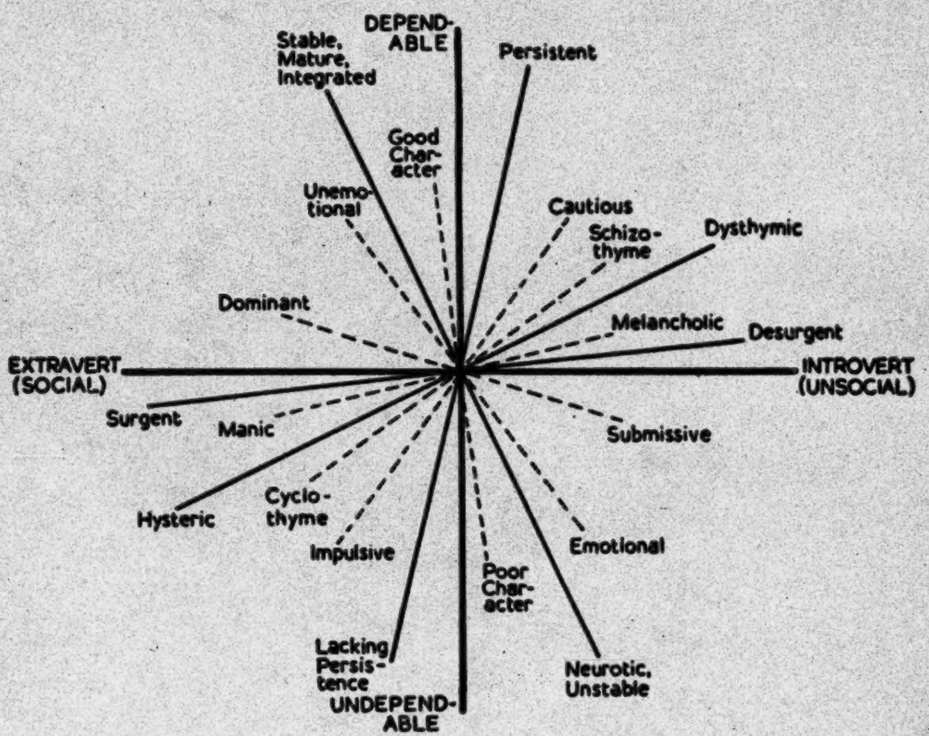

Fig. 6. Relationship between various personality traits (Vernon 1953)

by a spherical model. I have not done so to preserve the authenticity of the original concept.

Recently Schaefer (1966) has summarized a number of studies of parental behavior and proposed a three dimensional model, which is shown in Figure 7. The two best established dimensions are: acceptance versus rejection and encouragement of autonomy versus control. They were discussed by Schaefer (1961) for their implication for child behavior and Becker & Krug (1964) developed a model for child behavior which fits into Schaefer's two dimensions. Schaefer's third dimension is firm control versus lax control (consistent versus inconsistent forming part of this distinction).

It occurred to me, after reading the paper by Becker and Krug, that one might use Schaefer's <u>three</u> dimensional model to attempt to fit it together with Heymans'

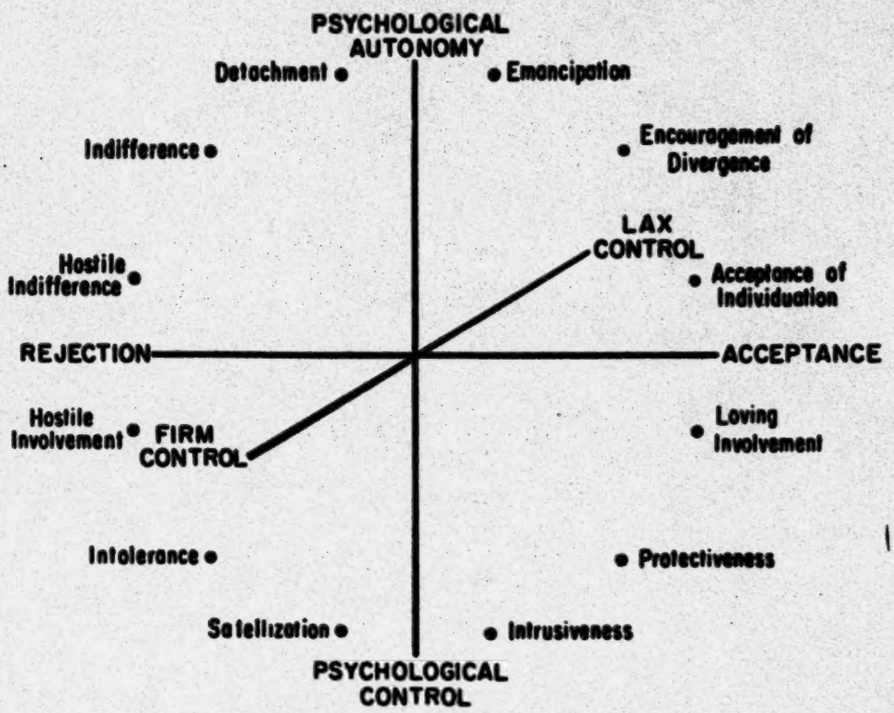

Fig. 7 Three dimensions of parental behavior (Schaefer 1966).

three dimensions as follows: acceptance and love would lead to easy expression of emotions in children, rejection and hate to blocking of emotional expression. Encouragement of autonomy would lead to development of activity and initiative, control and intrusiveness to dependence and formation of routine habits. Firm control would favor the development of predominantly secondary function and lax control would not, in fact it might develop opportunism and haphazard behavior.

As a tour de force I have placed Heymans' cube inside Schaefer's sphere. This is shown in Figure 8. This is not a space vehicle, but an attempt to show what seems to me a remarkable degree of correspondence between two entirely different lines of research.

For this reason I will use the three suggested major axes of human behavior variability as my "points de repère". They may be somewhat wobbly, but they have been useful to me on my voyage through psychological space.

Heymans' Personality System fitted into Schaefer's Model of Parent Behavior

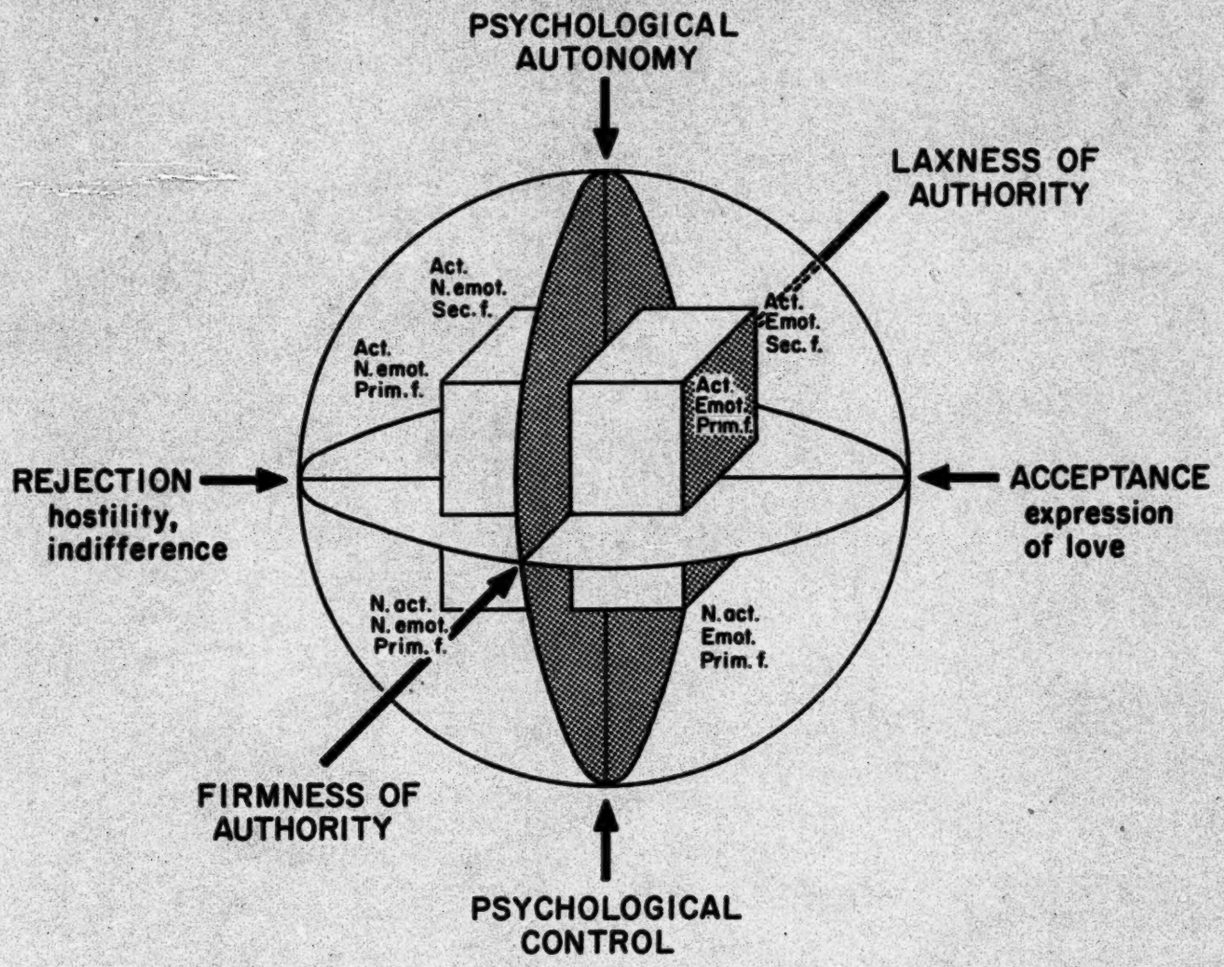

Fig. 8. Heymans' personality "cube" fitted into Schaefer's "sphere" of parental behavior.

Tryon (1965) has presented a three dimensional reduction of the MMPI. It would be challenging to see how this fits in with Heymans' model.

The two dimensional schema of Schlosberg (1962) for facial expressions bears a marked resemblance to the first two dimensions of Schaefer's model. If one added a third dimension of intensity it might correspond exactly. There is nothing special about the number three, but three factors often account for a very large proportion of the total variance, and other distinctions are bound to be minor and difficult to make unless some of the variance of the three factors is being slipped back in.

A final remark before we start surveying findings of hereditary factors in personality. I have intentionally suggested by this cube and sphere model that parents do influence the formation of their children's personality. Because a child usually has two parents we should have two spheres which occupy, to a considerable extent, the

same space, but might have their centers some distance apart. Individual fathers and mothers would not necessarily have corresponding positions in their own spheres, thus creating tension in the child. It would take another long paper to survey even part of the large literature on this. Suffice it is to say here that twin studies investigate the effect of hereditary components interacting with these parental influences.

Twin Studies of Personality

In 1935 Carter reported intraclass correlations for 55 identical (MZ) and 44 like-sexed fraternal (DZ) twin pairs on six scales of the Bernreuter Personality Inventory. From these correlations one can calculate Holzinger's heritability index from which in

$$H = \frac{r_{MZ} - r_{DZ}}{1 - r_{DZ}} \qquad (1)$$

turn a ratio between the fraternal and identical within-pair variances can be estimated (Vandenberg 1966a) by the approximation

$$F = \frac{1}{1 - H} \quad . \qquad (2)$$

This F is the usual F test for which probability levels are tabulated in most statistical textbooks. Table II shows the intraclass correlations, and the values of H and F for the twins in Carter's study.

Table II.
Intraclass correlations and values of H and F for six scales of the Bernreuter Personality Inventory (Carter 1935)

Scale	r_{MZ}	r_{DZ}	H	F
Neuroticism	.63	.32	.46	1.85*
Self-sufficiency	.44	-.14	.51	2.04**
Introversion	.50	.40	.17	1.20
Dominance	.71	.34	.56	2.27**
Self-confidence	.58	.20	.48	1.92**
Sociability	.57	.41	.27	1.36
Number of pairs	55	44		

*p < .05

**p < .01

There appears to be a significant hereditary component in the scores on scales measuring self-sufficiency, dominance and self-confidence. Without a detailed analysis of the items, it would appear that these are closely related concepts dealing with ego strength which do not fit well into the personality scheme just outlined, which is a serious defect of the scheme. There may also be a considerable hereditary factor in neuroticism as measured in this test.

In Newman, Freeman and Holzinger's classic study of twins (1937) the Woodworth-Matthews test of neurotic symptoms was used. The intraclass correlations were .56 for the MZ and .37 for the DZ twins, which is compatable with an hereditary component, but not strong evidence.

Eysenck and Prell (1951) used factor analysis to obtain scores on a "neuroticism" factor and obtained concordance correlations of .85 for MZ and .22 for DZ twins. The tests which most contributed to this factor were static ataxia, autokinetic movement, and suggestibility. The intraclass correlations for these separate tests were .86, .74 and .73 for the MZ; and .54, .13 and .23 for the DZ which gives H values of .69, .70 and .65.

These results are also difficult to integrate with the proposed personality scheme. It may be possible that this neuroticism factor leads to behaviors similar to those measured by the Bernreuter neuroticism scale and the Woodworth-Matthews scale. In that case, there is some further evidence for an hereditary component in neuroticism. The nature of the tests used by Eysenck suggests the speculation that mature, self-confident, self-sufficient and dominant individuals may score differently on these tests than do persons of the opposite make-up. But these traits, as measured by the Bernreuter showed a significant hereditary component. I am suggesting that there may be the following relationship. Eysenck's tests measure, perhaps, something related to Witkin's field dependency dimension, (Witkin et al. 1954, 1962).

Later, Eysenck (1956) isolated, through factor analysis of a variety of tests, including individual laboratory type procedures, a bipolar dimension of extraversion-introversion and found increased concordance for MZ compared to DZ twins of the order of magnitude usually reported for intelligence. These results fit in well with our proposed

scheme of major personality dimensions. It would, from this study, appear that extraversion-introversion has a very considerable hereditary component.

In 1963 and again in 1965 Gottesman administered the Minnesota Multiphasic Personality Inventory (MMPI) to adolescent twins. Recently Reznikoff and Honeyman (1966) also administered the MMPI to adult twins. However, their sample was rather small, which may explain why their findings appear to be out of line with those of Gottesman. Table III summarizes these findings for the ten basic scales. The first

Table III.

F ratios of DZ and MZ within-pair variances for twins from Minnesota, Massachusetts and Connecticut on the Minnesota Multiphasic Personality Inventory.

Hypochondriasis	1.19	1.01	2.33*
Depression	1.81*	1.82*	1.62
Hysteria	.86	1.43	2.70*
Psychopathic deviate	2.01*	1.63*	1.54
Masculinity-femininity	1.18	1.41	2.37*
Paranoia	1.05	1.61*	1.78
Psychasthenia	1.58	1.46	.82
Schizophrenia	1.71	1.49*	1.40
Hypomania	1.32	1.15	1.65
Social introversion	3.42**	1.49*	2.02
	34 DZ 34 MZ Gottesman (1963)	68 DZ 83 MZ Gottesman (1965)	16 DZ 18 MZ Reznikoff and Honeyman (1966)

* $p < .05$
** $p < .001$

thing to notice is that, with only two exceptions, all values are greater than unity, reflecting the fact that MZ were more concordant than the DZ on all scales. Only a limited number of values reached statistical significance, however. The values obtained in the Reznikoff and Honeyman study are frequently high enough so that they would become significant if the sample size had been larger. In order to estimate what the results would have been if the data from these studies had been combined, I converted all intraclass correlations to z, averaged these values and read the corresponding values of r from an r to z table. These values were then inserted in formulas 1 and 2 mentioned

earlier. (The values for F especially are not as accurate as would be obtained from a direct calculation of the ratio between the fraternal and identical within-pair variances $F = \frac{1}{N}\Sigma d^2_{DZ} \quad \frac{1}{N}\Sigma d^2_{MZ}$ where d is the difference between twin A and B.) The resulting values are shown in Table IV. The scales have been ordered in terms of the

Table IV.

Values of r_{MZ} and r_{DZ} for combined MMPI samples from Gottesman (1963, 1965) and Reznikoff and Honeyman (1966) averaged after z-transformation and estimated values of H and F.

	r_{MZ}	r_{DZ}	H	F
Social introversion	.45	.12	.37	1.59**
Depression	.44	.14	.35	1.53**
Psychasthenia	.41	.11	.34	1.52**
Psychopathic deviate	.48	.27	.28	1.39*
Schizophrenia	.44	.24	.27	1.36*
Paranoia	.27	.08	.21	1.27
Hysteria	.37	.23	.19	1.23
Hypochondriasis	.41	.28	.17	1.21
Hypomania	.32	.18	.17	1.21
Masculinity-femininity	.41	.35	.09	1.10
Number of pairs	120	132		

* $p < .05$

** $p < .01$

L scale (Lie scale)	.46	.17	.35	1.55**
F scale (Validity check)	.40	.38	.03	1.03
K scale (Defensiveness)	.35	.20	.18	1.23
Es scale (Ego strength)	.41	.41	.00	1.00

F ratio. Using these combined results one would conclude that the following scales show a statistically highly significant hereditary component: Depression, Psychasthenia and Social Introversion. F values for Psychopathic deviate and Schizophrenia are also indicative of an hereditary component, but not at the same high level of statistical significance. In terms of our personality scheme we note again that strong evidence for some hereditary determination of Social Introversion and the, perhaps, related find of

significance for the schizophrenia scale. Unpublished results graciously furnished by the authors allows me to include results on four other scales which are shown at the bottom of Table IV. There is an F value significant at the .05 level for the L scale. Perhaps this scale is related to neuroticism.

One may speculate about the causes for the fluctuations in value between the three samples. Until recently I had a personal thing, a prejudice if you wish, against administering the MMPI to high school students. I did not wish to run the risk of unfavorable reactions of parents to reports by the twins about the intrusive nature of some of the MMPI items. This prejudice was removed, in part, by a paper presented by Tellegen and Butcher at the 1966 meeting of the Midwestern Psychological Association. They actually asked subjects to indicate which items were objectionable by skipping them. While the number thus marked varied considerably between subjects, the number of items objected to 20 percent of the time or more was only 12. One can perhaps remove these items and prorate the scores, when using the test with high school students.

Let us return to a discussion of the discrepancies between the three MMPI twin studies. In view of this rather small number it does not seem probable that objections to some MMPI items and chance answers to these items could explain the varying results. Three—not mutually exclusive—possibilities remain: (1) The MMPI may not be accurate enough to provide reliable twin differences. (2) The twin samples represent different proportions of individuals who obtained scores that were high enough to allow for some sizable twin differences for fraternal pairs. Information would be needed about the MZ and DZ means and sigmas in each group to dismiss this possibility. (3) As Gottesman (1963, 1966) has pointed out, the importance of hereditary components may differ between the sexes. Different proportions of males and females in the three samples would then produce fluctuations in H and F values.

There has been one other instance in which the same personality questionaire has been administered three times, namely by Cattell et al. (1955), Vandenberg (1962) and Gottesman (1963). This was the High School Personality Questionaire of Cattell. It should be noted that different editions of the questionaire were used in each study. While these editions do not differ a lot, there were some changes made in the items in each

edition, so that the tests are not identical. This may explain, in part, the different results shown in Table V. The values for F were computed from the reported within-pair variance of the DZ and MZ twins. There is again considerable fluctuation in the

Table V.

F ratios for fraternal and identical within-pair variances on 11 scores of the High School Personality Questionaire.

Name of Score	Cattell 1955	Vandenberg 1962	Gottesman 1963
I Tenderminded vs toughminded	1.47	.97	1.07
Q4 Nervous tension vs autonomic relaxation	1.56*	2.08**	.53
C General neuroticism vs ego strength	1.60*	3.20**	1.03
Q3 Will control	1.08	1.87*	1.53
D Impatient dominance	1.35	.93	.62
A Cyclothymia vs schizothymia	1.08	1.30	1.11
H Adventurous cyclothymia vs withdrawn schizothymia	1.34	.93	1.62
K Socialized morale vs boorishness (Education minded)	1.39	1.06	----
E Dominance vs submissiveness	.90	.97	1.44
J Energetic conformity vs quiet egocentricity	1.57*	1.56	1.41
F Surgency vs desurgency	1.47	1.45	2.29**
Number of DZ pairs	32	37	34
Number of MZ pairs	52	45	34

** $p < .01$

* $p < .05$

values between the three studies. Table VI. shows what the F values are when the studies are combined.

Looking at these combined samples there is good evidence for an hereditary component in factor F, surgency, which, as best I can determine, is matter of optimistic mood and vital energy to use terms which fit into the proposed model. There are also results beyond the .01 level for factor C, neuroticism vs ego strength, which fits in with the findings of Carter on the Bernreuter, and the less clearcut results with the Woodworth-Matthew by Newman, Freeman & Holzinger, and Eysenck's results. Finally, also at the

.01 level, there is factor J, energetic conformity versus quiet ego centricity. These characteristics form part of the extraversion-introversion dimension. However, there are two other factors which are related to the extraversion-introversion dimension, namely H, adventurous cyclothymia versus withdrawn schizothymia and A, cyclothymia versus schizothymia. Only the first of these shows an F significant at the .05 level. Finally Q3, will control, has an F at the .05 level.

Table VI.

F ratios for combined samples of MZ and DZ twins on the High School Personality Questionaire (scales ordered for size of F).

Factor	Name	F
F	Surgency vs desurgency	1.96**
C	General neuroticism vs ego strength	1.71**
J	Energetic conformity vs quiet egocentricity	1.58**
H	Adventurous cyclothymia vs withdrawn schizothymia	1.42*
Q3	Will control	1.38*
A	Cyclothymia vs schizothymia	1.26
E	Dominance vs submissiveness	1.26
I	Tender minded vs tough minded	1.23
Q4	Nervous tension vs autonomic relaxation	1.23
Ka)	Socialized morale vs boorishness	1.22
D	Impatient dominance	.91

Number of DZ pairs 102

Number of MZ pairs 137

A. not included in Gottesman's study, $N_{DZ} = 68$, $N_{MZ} = 97$

* $p < .05$

** $p < .01$

It would appear that the HSPQ is tapping considerable hereditary variance, but the scales do not correspond in a clear-cut fashion to the concepts used in other studies.

It would be interesting to study DZ and MZ concordance item by item as Loehlin (1955) has done and thus to construct genetically more homogeneous scales.

In his 1962 study, Vandenberg also administered the Thurstone Temperament Schedule and obtained the results summarized in Table VII. The H and F values were calculated from the within-pair variances, rather than from the intraclass correlations,

but the latter are given for their own interest, since they are a direct indication of twin similarity. There is strong evidence for an hereditary component in the behavior(s)

Table VII.

MZ and DZ intraclass correlations and H and F values for the Thurstone Temperament Schedule (Vandenberg 1962).

Scale	r_{MZ}	r_{DZ}	H	F
Active	55	-06	67	3.01**
Vigorous	58	00	59	2.43**
Impulsive	44	-12	46	1.84*
Dominant	61	23	20	1.25
Stable	10	08	31	1.45
Sociable	50	-06	47	1.90*
Reflective	55	28	06	1.06
Number of MZ pairs	45			
Number of DZ pairs	35			

* $p < .05$

** $p < .01$

measured by the scales labelled active and vigorous. These would seem to be very close in meaning to the proposed major personality dimension labelled variously activity or vital energy. There is some evidence for a part-way hereditary determination of the behavior measured by the scales impulsive and sociable. We have seen earlier evidence for some hereditary component in sociability or extraversion, and impulsivity may be related to predominance of primary function.

An interesting finding was reported by Wilde (1964). He studied 130 pairs of twins ranging in age from 13 to 69 years of age, and thought of analyzing separately the results for twins still living together, and for those who were no longer living together, probably because they had set up their own family. The questionaire he used was the Amsterdam Biographical Questionaire which enquires about psychoneurotic complaints (N-score), psychosomatic complaints (NS-score), and introversion versus extraversion (E-score). A T-score checks on the test-taking attitude i.e. is the examiner self-critical or rather more defensive. This is somewhat similar to both the K scale or the Lie scale of the MMPI. An MF score measuring masculinity or femininity was derived

empirically from other data on the percentages of endorsement for each item by males and by females. He found the intraclass correlations for twins living together (T) and apart (A) shown in Table VIII.

Table VIII.
Intraclass correlations for MZ and DZ twins living together (T) or apart (A) on five personality scales (Wilde 1964).

		MZ		DZ	
		T	A	T	A
N	Psychoneurotic complaints	.55	.52	-.14	.28
NS	Psychosomatic complaints	.46	.75	-.05	.64
E	Extraversion - Introversion	.58	.19	.19	.36
T	Test taking attitude	.48	.46	.33	.49
MF	Masculinity - femininity	.45	.44	-.34	.30
	Number of pairs	50	38	21	21

It is interesting to note that the MZ twins living apart were more similar than those living together on the psychosomatic complaints and less similar on the extraversion-introversion score. This indicates that the relative importance of environmental influences on these behaviors was different for the two samples. A consequence of this shift is that one would have to conclude that the hereditary component in psychosomatic complaints is greater, or at least more directly expressed, in the MZ twins living apart than in those living together, and the reverse for extraversion-introversion. It is fairly easy to see how living together may tend to keep MZ twins more alike in extraversion-introversion, and how their individual life histories after setting up of separate families amy tend to make them less similar, but it is difficult to think of a reasonable explanation of the reverse findings for the psychosomatic complaints.

The differences between the DZ twins living together and those living apart are much more arresting. The most marked differences occurred in somatic complaints (-.05 for DZT and .64 for DZA), and masculinity-femininity (-.34 for DZT and .30 for DZA). Wilde suggested the possibility that DZ twins, while living together, may develop somewhat different behavior patterns in order to emphasize their individuality, but that their "true" personality would reassert itself after they go their separate ways, and that these true personalities would be more similar. It is true that the data do suggest this,

but it is very hard to believe that the same reasoning would not apply even more for the MZ twins, yet it is not clearly observed there. It would be necessary to exclude the possibility that age differences, or other differences, between the samples, rather than the fact whether or not twins lived together, were responsible, before one can conclude that DZ twins living together do not show their true personality, hence cannot be used to estimate the joint affect of within-family environmental and hereditary differences which is to be contrasted with the effects in MZ of within-family environmental differences. Wilde did conclude that his results could not provide a conclusion about hereditary components in the traits measured. Earlier he had, nevertheless, analyzed the significance of the greater MZ concordance compared to the DZ concordance and found the following p values: N .002, NS .056, E .25 and T .55. These values were derived from a new procedure employed by Wilde in which the fact was considered that in his data the distribution of individual scores were not similar for the DZ and MZ persons. He calculated a chance distribution of differences and evaluated how far the observed distributions of DZ and MZ differences departed from these chance distributions by the Mann-Whitney or the Smirnov-Kolmogorov tests.

If we perform a more conventional analysis of the intraclass correlations reported by Wilde, we obtain the results shown in Table IX. These results actually provide good

Table IX.
Intraclass correlations for the combined MZ and DZ twins, as well as value of H and F for the twins living together (T) or apart (A) and combined groups (C). (after Wilde 1964)

	r_{MZ}	r_{DZ}	H			F		
			T	A	C	T	A	C
Psychoneurotic complaints	53	11	55	33	47	2.22*	1.49	1.89**
Psychosomatic complaints	67	34	46	31	50	1.86*	1.45	2.00**
Extraversion-introversion	37	35	48	20	03	1.92*	1.00	1.01
Masculinity-femininity	44	02	45	20	43	1.80*	1.25	1.76*
Test taking attitude	46	54	22	00	00	1.29	1.00	1.00
Number of pairs	88	42						

* $p < .05$
** $p < .01$

evidence for an hereditary component in the psychoneurotic complaints score and the psychosomatic complaints score and perhaps for the masculinity-femininity score. When we look at the extraversion-introversion results, it depends on the age range. For the twins still living together one would conclude that there is an hereditary component. For the twins living apart, who were presumably older, there is little concordance left for the MZ and somewhat more for the DZ, providing no evidence for an hereditary factor. In the combined sample we find the same over-all concordance on E for both types of twins. The unexpected increased concordance in fraternal twins who no longer live together over those who still do has, I believe, not been reported before. One wonders if this is merely due to differences in the age distribution; perhaps differences in those personality traits are responsible, which contribute to the process of setting up one's own household either as bachelor or married person. In any case, this finding is worth further study and may contribute to a fuller understanding of studies of older twins.

Sometime ago we administered a questionaire based on Jung's typology (Vandenberg, Stafford et al. 1966). This questionaire is called the Myers-Briggs Type Indicator (Myers 1962). It provides scores for four bipolar traits shown in Table X with the obtained values for H and F. We hope to increase the number of twins to make these results more definite. As the results now stand, they provide further evidence for an hereditary component in extraversion-introversion.

Table X.
F ratios for fraternal and identical within-pair variances and values of H on the four scales of the Myers-Briggs Type Indicator for 27 like-sexed DZ and 40 MZ twin pairs.

Name of Scale	F	H
Extraversion - Introversion	1.84*	.46
Thinking - Feeling	.80	.00
Judgment - Perception	.76	.00
Sensing - Intuition	.70	.00

* $p < .05$

On another occasion we administered the Activities Index (Stern 1958, 1963) to 88 high school twins. See Stern et al. (1956) for a description of this personality questionaire. Table XI presents the F ratios for boys, for girls and for all cases, on the 30

Table XI.

F ratios between fraternal and identical within-pair variances on 30 scores of the Stern High School Activities Index for high school twins.

	Variable	Boys	Girls	All Cases
1	Abasement	1.33	1.24	1.21
2	Achievement	.95	1.00	.92
3	Adaptability	1.34	.87	1.08
4	Affiliation	1.98	1.26	1.54
5	Aggression	.58	.99	.78
6	Change	1.82	2.46*	1.74*
7	Conjunctivity	1.53	2.45*	1.78*
8	Counteraction	1.33	.95	1.10
9	Deference	1.10	.65	.84
10	Dominance	1.10	1.41	1.26
11	Ego Achievement	1.54	.99	1.20
12	Emotionality	3.14**	.99	1.70*
13	Energy	.76	1.09	.94
14	Exhibitionism	1.23	2.90**	2.03**
15	Fantasied Achievement	1.73	1.79	1.65*
16	Harm Avoidance	1.07	3.19**	1.67*
17	Humanities	4.03**	1.50	2.54**
18	Impulsiveness	.98	.97	1.01
19	Narcissism	.91	.95	.90
20	Nurturance	1.01	3.34**	1.70*
21	Objectivity	.98	1.58	1.12
22	Order	.88	2.16*	1.19
23	Play	.89	.83	.90
24	Practicalness	1.18	1.46	1.23
25	Reflectiveness	2.44*	.86	1.48
26	Science	1.08	2.43*	1.46
27	Sensuality	1.95	2.44*	2.20**
28	Sexuality	1.76	2.53*	2.06**
29	Supplication	1.75	1.28	1.50
30	Understanding	1.12	.60	.82
	Number of DZ pairs	16	22	38
	Number of MZ pairs	28	22	50

* $p < .05$

** $p < .01$

scores this questionaire provides. These scores measure "needs" based on the theories of Murray (1938). For the boys there are two F values significant beyond the .01 level and one F beyond the .05 level. This is somewhat more than chance expectation. In addition, several other variables have F values which might in a large sample have been significant. There is thus good evidence for hereditary determination in part, in boys for Emotionality which is one of the major axes in our proposed integrated personality scheme, and for an interest in Humanities (which may also reflect an interest in feelings and their expression). Perhaps the fact that these are in current American culture not considered part of the manly stereotype, but are part of the feminine one, has something to do with the presence in boys, but not in girls, of an indication of an hereditary component. The evidence for an hereditary factor in reflectiveness (in boys) is only at the .05 level of significance. Could this be our old friend introversion?

For the girls there are three F values at the .01 level and six at the .05 level. They are all different from those mentioned for the boys (although several approach significance for the boys). At the .01 level we find Exhibitionism, Harm Avoidance and Nurturance. I see no way of relating these to earlier findings except that Nurturance may also be somewhat related to easy expression of feelings and extraversion. At the .05 level are Change, Conjunctivity, Order, Science, Sensuality, and Sexuality. I will not attempt to discuss these results. When the sexes are combined we begin to have respectable size samples of MZ and even of DZ. (The latter are, as you may have noticed, frequently scarcer in twin studies).

There are four F values significant at the .01 level and five at the .05 level of significance. They are, in order of importance: Humanities (2.54), Sensuality (2.20), Sexuality (2.06), Exhibitionism (2.03) and at the .05 level: Conjunctivity (1.78), Change (1.74), Emotionality (1.70), Nurturance (1.70), Harm avoidance (1.67).

The interpretation of hereditary components in these scores is difficult. Some of them may be related to expression of feelings and acceptance of one's own feelings, but, for instance, the fearful attitude measured by Harm avoidance does not fit into this unless it is related to neuroticism. One would have to go back to the items scored for this scale and check DZ and MZ concordances for single items to see what the meaning might be.

Because these tests were machine scored by Dr. Stern, we had no opportunity to do so.

On the basis of a factor analysis of scores of college students, Stern (1965) has reported that the 30 scores of the activity index define twelve first order personality factors. These twelve personality factors and the scales contributing to them are listed in Table XII.

Table XII.

Activity Index scales contributing to the 12 first order factors.

Factor Title	Contributing Scales
1. Self-Assertion	Ego Achievement, Dominance, Exhibitionism, Fantasied Achievement
2. Audacity-Timidity	Risk-taking, Fantasied Achievement, Aggression, Science
3. Intellectual Interests	Reflectiveness, Humanities-Social Sciences, Understanding, Science
4. Motivation	Achievement, Counteraction, Understanding, Energy
5. Applied Interests	Practicalness, Science, Order
6. Orderliness	Conjunctivity, Sameness, Order, Deliberation
7. Submissiveness	Adaptability, Abasement, Nurturance, Deference
8. Closeness	Supplication, Sexuality, Nurturance, Deference
9. Sensuousness	Sensuality, Narcissism, Sexuality
10. Friendliness	Affiliation, Play
11. Expressiveness-Constraint	Emotionality, Impulsiveness, Exhibitionism, Sexuality
12. Egoism-Diffidence	Narcissism, Fantasied Achievement, Objectivity

The twelve first order personality factors are interrelated in a circular sequence frequently referred to as a circumplex (Guttman 1954). Four second order personality factors have been obtained from these twelve first order factors. These factors are named I. Intellectual Orientation, II. Dependency Needs, III. Emotional Expression and IV. Educability. It should be noted that the last factor overlaps in part with factors I and II. Their relationship to the twelve first order factors is shown in Figure 9. We obtained, from Dr. Stern, scores on these twelve first order factors and the four second order or "area" factors. Table XIII presents the F test results for these factor scores. Let us see if they are easier to interpret than the original scores.

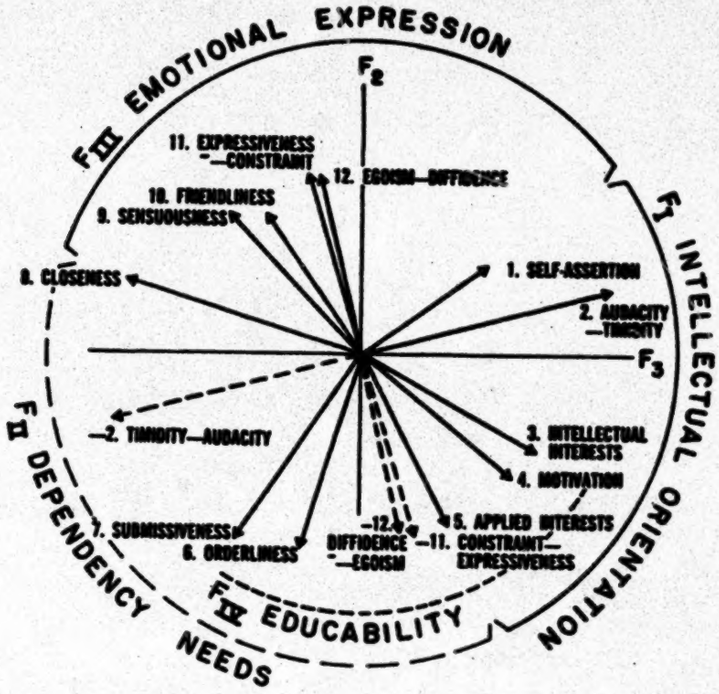

Fig. 9. The relation between 12 first order factors and 4 second order factors (Stern 1965).

For the boys there is one F significant at the .01 level: Intellectual Interests and one F at the .05 level: Sensuousness. The first one may be related to ability. Hereditary factors in ability have been well established (Vandenberg 1966). Hereditary factors in sensuousness have not been reported before, primarily because they have not been looked into before.

For the girls there is one F at the .01 level: Self-assertion. This is probably related to dominance for which Carter (1935) found evidence of an hereditary component. There are five F values at the .05 level of significance: Audacity-timidity, Applied Interests, Orderliness, Closeness and Sensuousness.

Many values which approached significance in either sex separately become significant when the two sexes are combined. There were three F values significant at

the .01 level: Intellectual Interest, Closeness, Sensuousness and five F values at the .05 level of significance: Self-assertion, Applied Interest, Orderliness, Expressiveness-constraint, Egoism-diffidence. The latter factor sounds similar to self-assertion yet is statistically uncorrelated with it, both may be psychologically related to dominance for which we found earlier evidence of an hereditary factor. For the other factors no hereditary component has been indicated before.

Table XIII.

F ratios between fraternal and identical within-pair variances on 12 factor scores and 4 area scores derived from the 30 scores on the High School Activities Index of G. Stern

	Factor Scores	Boys	Girls	All Cases
1	Self-assertion	1.73	3.07**	1.95*
2	Audacity-timidity	1.09	2.31*	1.30
3	Intellectual Interests	3.36**	1.55	2.30**
4	Motivation	1.40	.69	.98
5	Applied Interests	1.44	2.39*	1.70*
6	Orderliness	1.18	2.76*	1.66*
7	Submissiveness	1.45	1.51	1.43
8	Closeness	1.98	2.57*	2.24**
9	Sensuousness	2.28*	2.34*	2.31**
10	Friendliness	1.63	.87	1.18
11	Expressiveness-constraint	1.55	1.64	1.66*
12	Egoism-diffidence	1.95	1.59	1.70*
	Area Score			
I	Intellectual Orientation	2.45*	1.98	2.08**
II	Dependency Needs	.77	1.39	.93
III	Emotional Expression	2.77**	2.27*	2.49**
IV	Educability	2.11*	1.63	1.75*
	Number of DZ pairs	16	22	38
	Number of MZ pairs	28	22	50

* $p < .05$
** $p < .01$

Table XI had some values less than 1.00. However, we may safely regard values such as .95, .89, etc. as not significantly different from 1.00, indicating no real difference in concordance between MZ and DZ twins. The question is whether a few of the

lower values such as .58 for Aggression (in boys), .65 for Deference (in girls) and .60 for Understanding (in girls) have any real meaning.

Dyadic Polarization in MZ Twins?

There has been much discussion in twin research about the twin situation itself. The degree to which one identical twin will dominate the other, or how much and how often twins will "permanently" divide up responsibilities and roles is not known, but fairly systematic observations, which I have not yet fully analyzed, seem to indicate that this phenomenon has been exaggerated. Parker (1964) has made similar suggestions in connection with psychiatric twin research, and Rosenthal's (1960, 1962) findings have some relevance and tend to fit in with my suggestion that we should question the frequently encountered idea that being a twin is in itself a danger to mental health. From my own observations I would guess that the reverse is more generally true, as long as exclusive association with the other twin does not occur. In the highly gregarious culture of today at least this is very unlikely to occur.

Gottesman (1966) has just published the results of a study in which high school age twins were administered the California Psychological Inventory. The results are shown in Table XIV.

I will discuss only the results for the combined sample. The results for the boys alone or girls alone are not too different for these, except that there are several F values significant at the .05 level for the girls, where the values are less than unity for the boys indicating more similarity for the DZ than for the MZ twins. These are self-control, achievement via independence and intellectual efficiency.

For the total sample there are four F values significant at the .01 level and four at the .05 level of probability. Out of a total of 20 scores that is a considerable number.

The scales have been grouped on the basis of a factor analysis. We note, first of all, a remarkable concentration of significant F values for the scales related to person orientation, extraversion and sociability. We note especially again dominance and sociability which we have met before. Under acceptance of cultural values we find two F

Table XIV.[+]

F ratios between fraternal and identical within-pair variances on the California Psychological Inventory (Gottesman 1966).

Scale	Factor	Boys	Girls	All Cases
Dominance		2.06*	1.71*	1.95**
Sociability	Person	1.65	2.30**	1.97**
Self-acceptance	orientation	1.93	1.72*	1.85**
Social presence	Extraversion	1.73	1.35	1.55*
Capacity for status	Sociability	1.22	1.52	1.34
Sense of well being		1.00	1.23	1.11
Good impression		1.53	1.67	1.60*
Socialization	Acceptance	1.39	1.53	1.48*
Self-control	of cultural	.86	1.89*	1.38
Tolerance	values	1.27	1.46	1.37
Communality	efficiency of	1.30	1.13	1.23
Responsibility	parental training?	.99	1.99	1.35
Achievement via independence		.83	1.86*	1.31
Intellectual efficiency	Achievement	.82	1.84*	1.22
Achievement via conformance		.55	1.29	.87
Psychological mindedness		1.71	1.31	1.46*
Femininity	Empathy	1.68*	1.17	1.36
Flexibility		.95	1.39	1.17
Originality		1.87*	1.89*	1.91**
Psychoneurotic		.60	1.38	.94
Number of DZ pairs		32	36	68
Number of MZ pairs		34	45	79

** $p < .01$

* $p < .05$

[+] From Gottesman, I.I. Genetic variance in adaptive personality traits. APA 1965, to appear in 1966.

values significant at the .05 level: Socialization and Good Impression. These probably both are strongly influenced by parental control, yet we find significantly greater differences on these scales for DZ than for MZ twins indicating an hereditary component. Perhaps it is the rebelliousness of inability to benefit from parental training which is partly hereditary? Among the remaining scales there is some evidence for an hereditary influence on empathy and good evidence for an hereditary component in originality. These are both new findings which should be checked with other measures because they have important implications.

In a Finnish study of drinking patterns in twins, the data shown in Table XV were obtained on a personality questionaire (Bruun 1966).

Table XV.

Intraclass correlations and F ratios between fraternal and identical within-pair variances for four personality traits and three variables in drinking behavior in a Finnish study of alcoholism (Bruun et al. 1966).

Questionaire score	Intraclass Correlations MZ	DZ	$F = \frac{\sigma^2_{wDZ}}{\sigma^2_{wMZ}}$
Sociability	51	26	1.69**
Need for achievement	19	12	1.10
Neuroticism	28	21	1.07
Aggressiveness	25	16	1.23
Number of pairs	157	189	
Behavior reports			
Frequency of drinking	61	32	1.64**
Average amount consumed	38	11	1.56**
Lack of control	35	27	1.16
Number of pairs	172	557	

* $p < .05$
** $p < .01$

Of the four personality variables Sociability shows again good evidence for an hereditary component, but Need for Achievement and Neuroticism did not. These were adult twins, frequently interviewed in the presence of a third person, which may have

influenced their responses. This may have affected questions relating to Neuroticism especially. The MZ concordances for these three variables were unusually low. Of the three variables dealing with drinking behavior two showed F ratios at the .01 level, but the one most important for the development of alcoholism did not. The authors conclude that there is an important hereditary element in drinking, but that the legal definition of alcoholism is too arbitrary and varies too much from one area to another to speak of an hereditary factor in alcoholism, legally defined.

Last spring we administered a shortened version of some personality and attitude variables developed by Comrey (1965, 1966). The results of the comparison of the fraternal and identical within-pair variances are shown in Table XVI. The scales

Table XVI.

F ratios between fraternal (DZ) and identical (MZ) within-pair variances of 12 scores on the Comrey Personality and Attitude factors.

Name of scale	$F = \frac{\sigma^2_{wDZ}}{\sigma^2_{wMZ}}$ Boys	Girls	All Cases
Achievement Need	1.91*	2.10**	2.20**
Shyness	2.83**	1.51*	1.94**
Compulsion	1.49	1.50*	1.50*
Dependence	1.25	1.15	1.15
Self-control	1.24	1.24	1.28
Empathy	1.46	1.18	1.28
Welfare State Attitude	1.71	1.04	1.27
Religious Attitudes	.84	1.86**	1.49*
Punitive Attitudes	.89	1.61*	1.27
Neuroticism	.77	1.32	1.23
Hostility	.93	.72	.82
Ascendance	.50	.89	.80
Number of DZ pairs	27	63	90
Number of MZ pairs	52	59	111

* $p < .05$
** $p < .91$

for Shyness and Achievement Need show the strongest evidence for an hereditary component. There is some suggestion of an hereditary component for Compulsion in both sexes, and for girls only in Religious Attitudes and Punitive Attitudes. We don't

have an explanation why these findings should be different for boys. Several possibilities suggest themselves, but there is no way of distinguishing between them.

We did explore whether there were differences in the means or variances between the sexes for these scores which might, in part, account for the discrepancy in F values for boys and girls. In fact we went one step further.

Sex Differences in Boy-Girl Twin Pairs

We wondered if belonging to a boy-girl twin pair would place one in an inbetween position as regards to sex differences. One might expect that the means for boys from such pairs would be slightly closer to those of girls and vice versa for girls. One would then expect the following order—or its reverse—for the means of the four groups:

1. BOYS FROM LIKE-SEXED PAIRS
2. BOYS FROM UNLIKE-SEXED PAIRS
3. GIRLS FROM UNLIKE-SEXED PAIRS
4. GIRLS FROM LIKE-SEXED PAIRS

The results of the analysis for the 12 scores on the Comrey scales are shown in Figure 10. The graphs in Figure 10 have been moved apart by adding ten points to the mean of group 2, 20 to group 3, and 30 to group 4. Without this the points would, in many instances, have overlapped.

We see first of all that sex differences cannot explain the different heritability estimates for the two sexes mentioned just above. We also see that there are no really important sex differences in personality in our sample. Several of the Comrey scales show statistically significant differences, but they are due to the fairly large sample sizes and the small standard deviations compared to the values for the means.

In the absence of sizeable sex differences a meaningful test of the hypothesis concerning the effect of belonging to boy-girl pairs was not possible.

Finally the high congruence between the four samples gives some confidence in the accuracy of the scales.

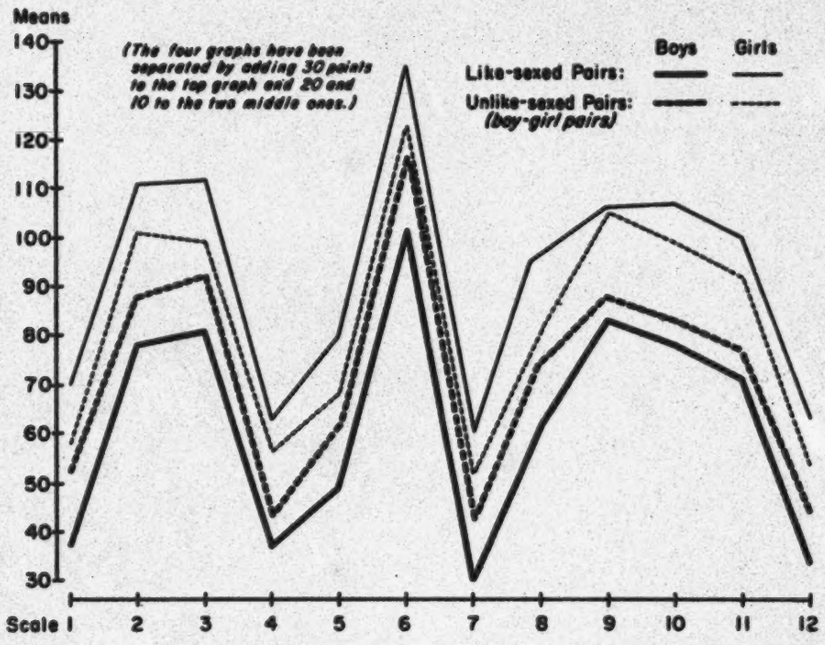

Fig. 10. Means on 12 personality and attitude scales for boys and girls from like-sexed and unlike-sexed twin pairs.

Sandra Scarr (1964) had mothers answer the Gough (1960) Adjective Check-list about their twins, who were all girls between six and ten years old, and rated the children on some parts of the Fels Child Behavior Scales (Richards & Simons 1941). She obtained the results shown in Table XVII. This is again very strong

Table XVII.
Intraclass correlations and values of H and F on some sociability variables.
(Scarr 1964)

Variable	r_{MZ}	r_{DZ}	H	F
ACL Need for affiliation	.83	.56	.61	2.56**
ACL Counseling readiness	.56	.03	.55	2.22*
Fels scale Friendliness	.86	.36	.78	4.55**
Fels Social Apprehension	.88	.28	.83	5.88**
Rating Likeableness	.93	.82	.61	2.56**
Number of pairs	24	28		

Stability of Twin Differences

We have touched several times on the question whether twin differences are

stable. This question is of considerable importance for several reasons. First of all, because one would expect a trait which is determined to a significant degree by genes, to be more stable than one which is not. It is true many personality traits can probably be influenced by interpersonal relations and therefore may be subject to long range and perhaps even short range shifts. Nevertheless, the results of the longitudinal studies at Berkeley, at the Fels Institute and elsewhere show that certain personality constellations are remarkably stable, Honzik (1964), Kagan & Moss (1962), Schaefer & Bayley (1963), Tuddenham (1959) and McKee & Turner (1961). Especially shyness and introversion or its opposite sociability and extraversion seems to be rather stable over time.

Another reason why information is desirable about the stability of twin differences concerns the heart of the twin study methodology. Nobody but fanatical environmentalists would deny that 1. fraternal twins are less similar than identical twins; 2. that this is in large measure a consequence of the fact that they receive on the average 50% different genes. What is not so clear is whether the personality differences of twins are a direct consequence of these different genes, or whether they are, to an important degree, the result of the repeated reactions of each twin to behaviors displayed towards them; behavior which include differential patterns of response, from birth on, to the hereditary differences in physique, temperament and whatever else may be truly innate. Twin research will be rather fruitless unless it can be shown that twin differences are relatively stable for most twin pairs over most of the life span, when unusual situations are excluded.

Data of this kind is hard to come by. Rutter, Korn & Birch (1963) in a longitudinal study obtained some indication for the stability of twin differences because they included three identical and five fraternal pairs, as well as 26 pairs of siblings. They found markedly different levels of stability over the first three years of life for the variables studied. Only the threshold for stimulation was fairly stable. There appeared to be greater changes during the third year.

Von Verschuer (1954) published a report on a follow-up of twins studied initially up to 25 years earlier, but it was mainly concerned with anthropometric measures and physical illness. The only psychological data with which I am familiar come from

Gottschaldt (1960). He was able to study 33 pairs of fraternal and 35 pairs of identical twins who had been studied intensively 15 years earlier when they took part in one of the camps held in 1936 and 1937 for twins only.

Twins were judged on a number of personality attributes. There is space here to mention briefly only the following four: Mood, vital energy (or activity), thinking capacity and level of abstraction.

Mood - The twins' predominant mood was rated at the camp and when they were adults as:

> 1. boisterous, excessive, unruly; 2. cheerful, gay; 3. lively, active, vivacious; 4. content, mood suited to the occasion; 5. quietly pleased, inner contentment; 6. easily upset or out of sorts; 7. morose, surly, sulking, grumbling; 8. weeping and wailing and 9. depressed and sad.

Figure 11 shows the degree of similarity or concordance for the identical and fraternal twins as adolescents and as adults. The letters a to h refer to a scale with unequal steps as follows:

> a. complete concordance
>
> b. small, unimportant quantitative differences
>
> c. clear quantitative differences
>
> d. clear qualitative differences
>
> e, f, g and h. medium through large differences.

The twins have been ordered so that pairs with small adult differences are on the left and those with large adult differences on the right.

Two things can be seen at a glance from this figure. First of all there are much more frequent large differences between the fraternal than between the identical twins, whether one considers the solid line (adults) or the dotted line (adolescents). The second thing to notice is that there are few instances of large shifts with age. In the top figure, where the fraternal twin differences are shown, many adult pairs are seen to have differences which are one category larger than when they were adolescents. The same thing is true to a lesser degree for the identical pairs. One may conclude

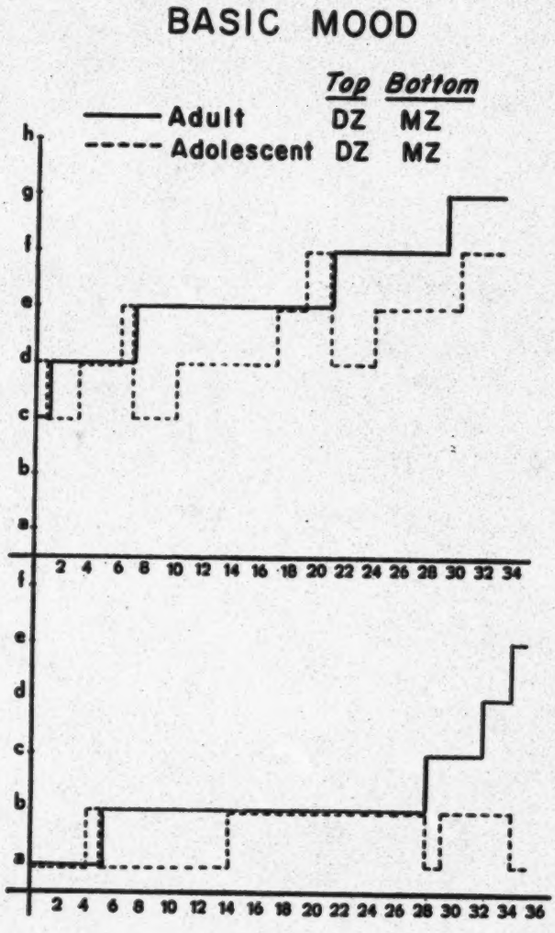

Fig. 11. Relative concordance rates of adolescent and adult identical (MZ) and fraternal (DZ) twins on mood (Gottschaldt 1960).

that twin differences are stable and that, if anything, the ratio of fraternal to identical within-pair variances would be larger for the adults than for the teenagers. This is truly impressive evidence for the importance of hereditary factors in the basic mood of an individual, even if no statistical analysis is reported. A chi square analysis could be done from the information in these graphs.

Vitality - Figure 12 presents the same type of information for vitality, or rated energy. Gottschaldt calls this part of the time biotonus and mentions personal tempo. We see again considerably greater differences for fraternal than for identical twins, and remarkably few drastic increases in the twin differences. One would judge that for vitality the F ratio would be about the same value at both ages.

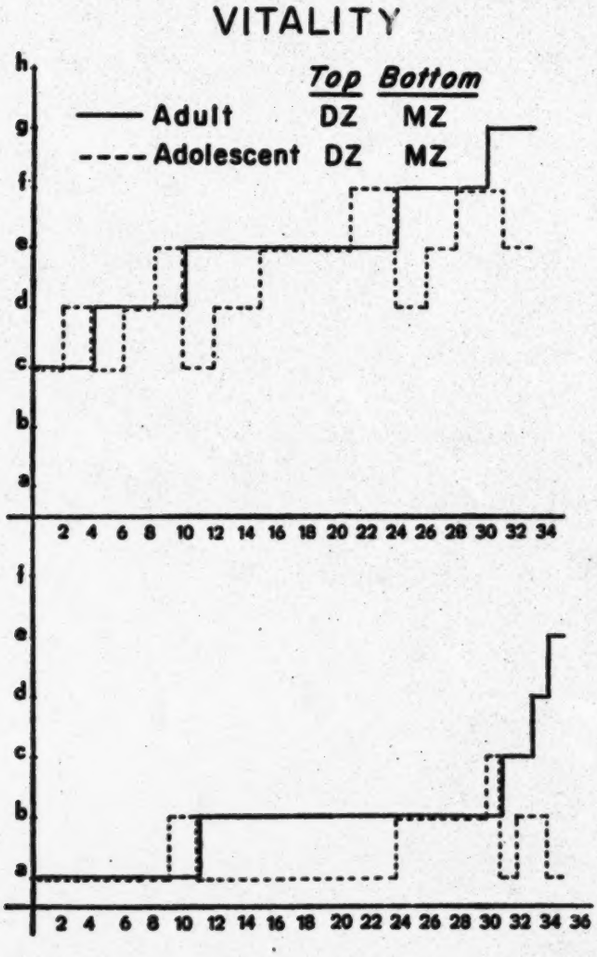

Fig. 12. Concordance rates on vital energy (Gottschaldt 1960).

For the sake of comparison, data on thinking capacity and level of abstraction are shown in Figures 13 and 14. They show similar results, except that the discrepancy between the size of the MZ and DZ twin differences is somewhat less for both traits. Thinking capacity refers to the breadth of intellectual interests and is a global appraisal of the subject's life experience, and his reactions to it, as well as his interests and social orientation. The level of abstraction is also a global appraisal.

Gottschaldt administered many types of tests in the earlier phase and reported some of these earlier, but from the 1960 report it is not clear if the twins were given any tests during the follow-up work.

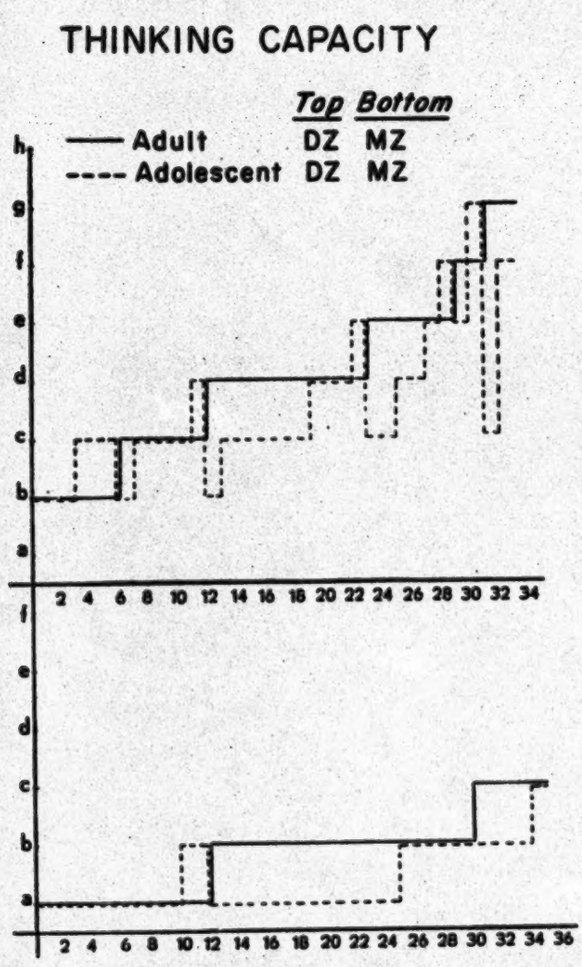

Fig. 13. Concordance rates on thinking capacity (Gottschaldt 1960).

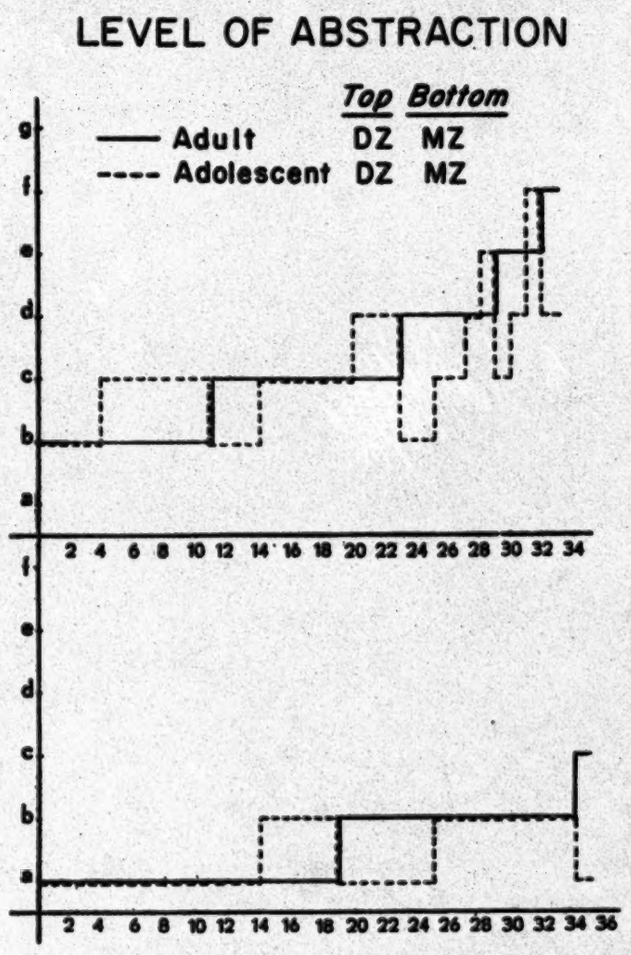

Fig. 14. Concordance rates on level of abstraction (Gottschaldt 1960).

Gottschaldt distinguished three types of behavior: 1. those directed mainly by subcortical areas, such as basic mood, emotionality and vital energy; 2. those directed more by cortical areas, such as abilities and problem solving, and 3. evaluation of self and society, life goals and attitudes based on education, experience and rational thought. He concluded from his work that the first type of behavior is remarkably stable and largely determined by genes. The second type of behavior is somewhat less stable because it is more influenced by the environment, not just in childhood, but all during life. As a consequence, genes determine the nature of this type of behavior less directly, which will be reflected in a reduced portion of the variance which can be attributed to heredity when H is calculated.

Finally, social orientation, Gottschaldt believes to be even less directly controlled by genes. We must distinguish this more cognitive expression of values and attitudes from the introversion-extraversion measured in the American studies reviewed above.

Summary and Conclusions

The possibility of truly integrating the many pieces of only partially conclusive data, on often not fully comparable variables in samples of different ages and sex distribution is rather remote.

By word magic I may occasionally have been able to suggest compatability, or even congruence when there is none in reality. Statistical manipulations are only valid if the underlying assumptions of the methods are met and this can sometimes not be verified.

Taking all this in to account, as well as the limitations pointed out at the start of this report, we can still be quite certain, I believe, that there are considerable hereditary components in personality. Throughout I have avoided estimation of the proportion of the variance accounted for by heredity. I believe that it is premature to do so at this time. Such estimates are a function of the particular group of twins studied and may vary quite a bit from sample to sample. The F test is less affected because the actual value in the results is not important, only the significance level.

You may ask yourself, as I often do, how good these personality tests are? Do they really measure what the names of the scales suggest? We can get some idea about this from studies in which one scale is correlated with another of the same name, and the results are frequently encouraging.

We can, however, also be rather sure that many of the questionaires are not very suitable for the study of heredity. They may not permit accurate assessment of twin differences, especially if these are small. Loehlin (1965) has suggested that the MZ and DZ concordance of single items be studied and that items with high MZ but low DZ concordance be used to construct new questionaires, which after cross-validation ought to be more suitable for genetic studies. One could go one step further and see

whether the same member of each pair of fraternal twins answers yes to two items which met the earlier criteria. If this is largely true, one may conclude that the items tap the same hereditary component, if false, the items must be related to different hereditary components.

Of the variables studied so far, we have encountered time and again evidence for a strong hereditary component in sociability or extraversion and its opposite introversion. Table XVIII,* which summarizes most of the results, shows this rather clearly. In terms of Heymans' three dimensions of activity, emotionality and primary versus secondary function, this is probably closest to the emotionality axis, which refers to normal expression of emotion rather than instability, with perhaps some admixture of activity.

We have also some evidence for an hereditary factor in emotionality itself and for activity. Evidence for the primary-secondary function is indirect. To the extent that this is related to impulsiveness, to introversion-extraversion and to educational achievement, there is some evidence for an hereditary component.

There was somewhat conflicting evidence about the importance of hereditary factors in neuroticism.

If we are willing to consider introversion as a normal variation of schizophrenia, then the rather consistent evidence for an hereditary component in introversion-extraversion scales provides support for theories claiming an hereditary basis for schizophrenia.

A final question which we can only raise here, not answer, is what the evolutionary significance of these personality variations has been and is. Perhaps they are merely the consequence of anatomical, physiological and biochemical variation resulting from different allelic combinations. On the other hand, getting along with people, getting things done and being able to analyze one's actions must have been of paramount importance during the gradual emergence of man, perhaps as much or more as the erect posture and freeing of the hands. Yet it is difficult to determine for specific traits how they contributed to

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* Table XVIII is not available for technical reasons—too big.

Table 18 Summary of findings from twin studies of personality questionaires

Author - year N_{DZ} N_{MZ} questionaire	Significance level of the increased DZ concordance		Not significant	$r_{MZ} < r_{DZ}$
	.01	.05		
Carter 1935 44 55 Bernreuter	Self-sufficiency Dominance Self-confidence	Neuroticism	Introversion Sociability	
Vandenberg 1962 35 45 Thurstone	Active Vigorous	Impulsive Sociable	Dominant Stable Reflective	
Cattell 1955 Vandenberg 1962 Gottesman 1963 102 137 HSPQ	Surgency Neuroticism Energetic conformity	Adventurous cyclothymia vs. schizothymia Will control	Cyclothymia Dominance Tender-tough minded Nervous tension Socialized morale	Impatient dominance
Gottesman 1963 Gottesman 1965 Reznikoff & Honeyman 1966 132 120 MMPI	Social introversion Depression Psychasthenia	Psychopathic deviate Schizophrenia	Paranoia Hysteria Hypochondriasis Hypomania Masculinity-femininity	
Wilde 1964 42 88 Amsterdam biographical quest.	Psychoneurotic complaints Psychosomatic complaints	Masculinity-femininity	Introversion Test taking attitude	
Vandenberg 1966 27 40 Myers-Briggs		Introversion		Thinking-feeling Judgement-perception Sensing-intuition
Vandenberg 1966 38 50 Stern Activity Index factors	Intellectual interests Closeness Sensuousness	Self-assertion Applied interests Orderliness Expressiveness-constraint Egoism-diffidence Educability	Audacity Motivation Submissiveness Friendliness	Dependency needs
Vandenberg 1966 90 111 Comrey	Achievement need Shyness	Compulsion Religious attitudes	Dependence Self-control Empathy Welfare state attitude Punitive attitude Neuroticism	Hostility Ascendance
Scarr 1966 28 24 Gough ACL Fels behavior list	Need for affiliation Friendliness Social apprehension Likableness	Counseling readiness		
Gottesman 1966 68 79 C. P. I.	Dominance Sociability Self-acceptance Originality	Social presence Good impression Socialization Psychological minded	Status capacity Sense of well being Self-control Tolerance Communality Responsibility Achievement via independence Intellectual efficiency Femininity Flexibility Psychoneurotic	Achievement via conforma
Bruun 1966 189 159 Special questionaire and interview	Sociability Frequency of drinking Average consumption		Need for achievement Neuroticism Aggressiveness Lack of control	Not reported

evolutionary fitness, except by rather loose analogy reasoning from animal genetics, or by intuitive deduction from man's history and prehistory. In fact, Skinner has suggested in an address at the University of Kentucky, that during evolution nature acts rather similar to the experimenter in a conditioning program: by reinforcing certain behaviors he may occasionally include meaningless and undesired features. One may speculate that we may have acquired by this "shaping" some superstitions about our own behavior repertory. Such superstitions may well be common to all or most cultures, so that even comparative analysis of personality theories in widely different cultures will provide no more valid ideas about basic personality dimensions and their importance. The manly virtues of aggressiveness and dominance may, for instance, have been of evolutionary significance at one time, but perhaps forbearance and tolerance would at present be more important for the survival of the human race.

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